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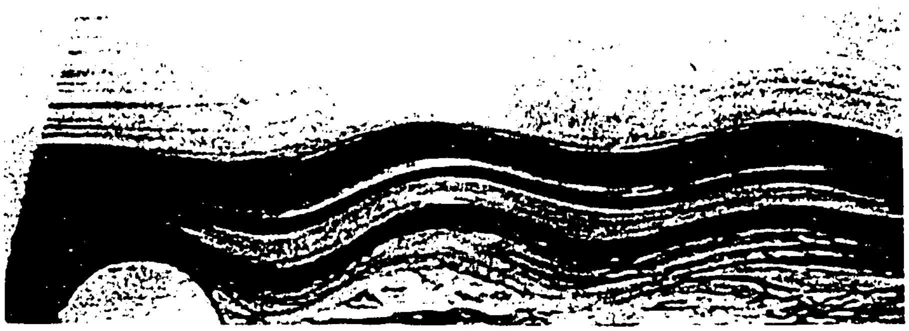
The 4th International Symposium on Stratified Flows follows the previous IAHR meetings in Novosibirsk, 1972, Trondheim, 1982 and Pasadena, 1987. The aim of the meeting is to advance the understanding of fluid motions and turbulent mixing influenced by buoyancy forces and combined effects of buoyancy and rotation.



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Convection and Internal Waves
in a Stably Stratified Shear Flow

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Wijesekera and Dillon (1991) hypothesized that internal gravity waves could be generated just below the upper ocean mixed layer as a result of convective plumes in the mixed layer. Furthermore they demonstrated that these waves could propagate downward and generate the secondary mixing events that are seen in the equatorial thermocline. We have designed a series of Large Eddy Simulations to test this hypothesis.

The domain for the Large Eddy Simulations consists of a surface turbulent boundary layer overlying a stably stratified region in the upper ocean. The boundary layer is forced by surface cooling with no wind stress. The surface cooling has a maximum value of 500 W/m^2 and the form of a double Gaussian with a half width of 27 m in the x direction and is uniform in the y direction. We impose a large-scale mean horizontal velocity field in the ocean by continually nudging the velocity field toward a prescribed vertical profile. The velocity profile varies in the vertical and allows for the possibility of critical layer absorption of the downward propagating gravity waves. The Coriolis force is set to zero to simulate equatorial conditions.

The model domain is 200 meters square in the horizontal and 100 meters deep. The numerical grid consists of 75^3 points with uniform spacing. The incompressible, Navier-Stokes equations are solved spectrally in the horizontal and a finite difference scheme is employed in the vertical. The diffusivity is variable and depends on the magnitude of the subgrid scale energy. A prognostic equation is solved for the subgrid scale energy. The horizontal boundary conditions are periodic. The vertical boundary conditions at the top of the model domain are the imposed fluxes of heat and momentum, at the bottom the boundary conditions radiate gravity waves out of the domain. The code is based on the atmospheric Large Eddy Simulation code of Moeng (1984).

The imposed surface cooling generates convection in the initially isothermal surface layer significantly increasing the

level of resolved scale turbulent kinetic energy. The energy is distributed among the normal Reynolds stresses as predicted by theory, the vertical component is the largest and the maximum value occurs at about mid-depth in the turbulent layer. The turbulent boundary layer deepens with time. The frequency spectra of the resolved scale fields have approximate -5/3 slopes in the boundary layer.

Below the boundary layer the results display a high frequency internal gravity wave field in the stratified region only when the mean shear is imposed on the flow. The wavelengths in the direction of mean shear are approximately 2-3 times larger than the wavelengths in the direction of no mean shear. The frequency spectra of the resolved scale fields peak near the buoyancy frequency in the stratified layer. There is a maximum in the resolved scale turbulent kinetic energy at the critical layer.

The resolved scale kinetic energy budget, heat-flux budget, and coherence and phase relations are calculated directly from the model data and will be used to further describe the physics of the wave field and the turbulent boundary layer.

References

Moeng, C-H., 1984: A large-eddy-simulation model for the study of planetary boundary-layer turbulence. *Jour. Atmos. Sci.*, **41**, 2052--2062.

Wijesekera, Hemantha W. and Thomas M. Dillon, 1991: Internal waves and mixing in the upper equatorial Pacific Ocean. *J. Geophys. Res.*, 96, 7115-7125.

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13. ABSTRACT *(Maximum 200 words)*
Wijesekera and Dillon hypothesized that internal gravity waves could be generated just below the upper ocean mixed layer as a result of convective plumes in the mixed layer. Furthermore they demonstrated that these waves could propagate downward and generate the secondary mixing events that are seen in the equatorial thermocline. We have designed a series of Large Eddy Simulations to test this hypothesis.

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